

Staff members' ideas about visitors' learning at science and technology centres

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Staff members’ ideas about visitors’ learning at science and technology centres

Abstract

This study investigates staff members’ ideas and assumptions about visitors’ learning at science and technology centres (STC). It also aims to explore in what ways their reasoning intersect with existing theories about learning within the field of STC research. The results of the study reveal that the staff members allude to learning processes differently by distinguishing organised from non-organised learning, theoretical learning from practical hands-on learning and serious from non-serious learning. According to most of the staff members, these also conclude with different learning outcomes. Further on, a majority of the staff members state that they do not have any scientific knowledge about learning despite the fact that they work with the construction of new exhibitions. When discussing visitors’ learning, the staff members instead refer to personal experiences, professional experiences, professional education and external references. When it comes to how they reason about the natural scientific content, nearly all express that they use references from the natural science community and researchers’ knowledge. The article moreover discusses in what ways a sociocultural approach may be used in order to understand how learning arises when visitors interact with exhibits.

Introduction

Only few studies investigate underlying assumptions to how exhibitions are planned and created at museums and science and technology centres (STCs). One example is Knutson’s (2002) research about the development of a temporary art and science exhibition. She found that staff members, depending on their educational background and professional role in the design team, had different notions about what the visitors should experience. Also Macdonald (1998) studied the construction of a science exhibition and found that assumptions, rationales and compromises that lead to the finished exhibition were not explicit to the visitors. In particular the relation between science and the societal and the political contexts tended to be overlooked as the staff members concentrated on practical and aesthetical matters of the task. She argues that this can lead to that the visitors experience the content of the exhibition as ready-made statements rather than descriptions of outcomes from scientific processes.

Staff members’ different agendas and their apprehensions about societal and

political contexts are thus two underlying assumptions which influence how exhibitions are constituted. But what assumptions about visitors' learning do staff members express and what consequences follow these when planning and constructing an exhibition? The purpose of this article is to investigate staff members' ideas about visitors' learning in relation to their exhibitions and to explore how their reasoning intersect with and are related to existing theories about learning within the field of STC research. Furthermore, it aims to study what references of knowledge staff members refer to when reasoning about visitors' learning and when reasoning about the scientific content.

Theoretical background

Approaches to learning in science and technology centre research

A considerable and dominating part of the research within the field of science and technology centres is studies concerning visitors' learning outcomes. What do visitors actually learn, understand or apprehend when visiting an exhibition? One example of these kinds of studies is one by Bishop and Reed (2005) where students participated in a course located at a STC. The study concludes that students through being engaged in activities at the centre developed an enhanced knowledge about the science content. Schauble et al (1997) argue that a problem with these kinds of studies is that the correlations between learning outcomes and the visit are not clear enough. It is hence not possible to assert that the learning outcomes are only related to the visit. An attempt to attend to this problem has been to conduct pre- and post-tests. One example is the study of Heard, Divall and Johnson (2000) where students, after a questionnaire pre-test about scientific facts and concepts, interacted with exhibits at a STC. The post-test concludes that the students achieved higher scores on the same questionnaire. Some evident shortcomings with such an approach are that the learning outcomes are not taken into consideration and discussed. This means that learning risks being seen only as an ability to render or reproduce non-contextual scientific facts and concepts. Another problem, according to Falk and Dierking (2000) is that these studies are not related to a theoretical framework for learning at STCs and do not have as their purpose the development of such a framework. Consequently this dominating paradigm has been criticized (Anderson et al, 2003; Schauble et al, 1997) for having weak or even a lack of theoretical frameworks, where learning is implicit and undefined. Paris and Ash (2000) and Schauble et al (1997) argue that this

shortcoming limits the possibility of making generalizations and comparisons to learning in similar settings. Another obvious problem is that this lack of a theoretical perspective of how visitors' learning is developed risks making learning implicit and invisible when staff members plan new exhibitions at STCs.

Theoretical models of learning in the context of STCs

However, different scholars have had as their **intention** the development of theoretical frameworks in order to describe crucial factors involved in the visitors' learning at STCs. A common assumption in these frameworks is the importance of the visitors' prior knowledge and experiences. For example Anderson et al (2003) relate to the constructivist perspective when emphasizing the learners' prior understanding of concepts that differentiate from scientific models of explanations. They argue that scientific ideas or misconceptions held by the individual are a result of previous personal experiences, observations of objects and events, culture, language and teachers' explanations. To be able to discern how visitors' understanding of scientific concepts are developed it is necessary to consider the visitors' previous experiences. Stocklmayer and Gilbert (2002) also emphasize that knowledge of the mental models visitors hold before their arrival is necessary in order to understand learning outcomes. They suggest a framework that intends to produce an understanding of scientific models called *PAST* (personal awareness of science and technology). This framework deals with the individual's learning from interactive exhibits as increased awareness of science and technology. They argue that their framework can probe visitors' experiences *beyond mere behavioral observations*. According to this framework an exhibit creates a link of remembrance between her earlier awareness and present experiences, which results in a new level of personal awareness. Further encounters with the same concept or phenomenon will lead to a stronger linkage and result in an even more refined personal awareness. To change the individual's personal awareness of science and technology, exhibits must be personally engaging, evoke powerful recall of current understanding and demonstrate an evident relationship with a concept or a phenomenon. The core in this reasoning derives from Ausubel's et al (1978) *Meaningful Reception Learning* and Hewson's (1981) *Theory of conceptual change*. A problem in these kinds of framework, according to Wertsch (2002) and Säljö (2005), is that learning risks being considered only as an intramental and individual phenomenon without regarding those cultural and social situations where learning occurs.

In *The contextual model* proposed by Falk and Dierking (2000), an

individual's prior knowledge is crucial in order to understand visitors' learning at museums and STCs. However their model also includes that the visitors' physical and sociocultural context affects their learning outcomes. The physical context deals with exhibit design, advance organizers and orientation, as well as reinforcing events and experiences outside the museum. This means that exhibition design and the surroundings need to be organized in ways where visitors are attracted to the exhibits, feel secure and are given opportunities to focus on the exhibition content. The sociocultural context mainly highlights human mediation within a group and mediation by others like curators. According to Falk and Dierking (2000) this means that museums create unique milieus for social groups to utilize each other for sharing information and reinforcing joint beliefs and for collaborative meaning-making. The model is used in a study by Falk and Storksdieck (2005) designed to find out what factors individually contribute to learning outcomes. The data consisted of pre- and post interviews of more than 200 adult visitors. The results of the study show that all of the factors in the contextual model influenced learning outcomes. It was however not possible to discern any single factor that better than others could explain learning outcomes across all visitors.

In order to further enhance the understanding of visitors' learning, recent studies have to a higher extent focused a sociocultural approach. Above all, this perspective has been used in order to develop methods for collecting data or as an analytic tool to be able to study the interactions between visitors as well as between curators and visitors. For example, Allen (2002) analyzes learning not from an individual, but from a group perspective and views learning as meaning making processes that emerge when visitors interact with each other. She argues that using visitors' talk as a methodology in research offers a rich description of what the visitors really do and talk about. In addition, this approach may be used to identify to what extent an exhibit facilitate or prevent visitors' conversations and interactions and from that suggest changes in exhibit design. In the study she recorded visitors' conversations and found that more than 80% of the talk could be referred to as *learning talk*, which she defines as perceptive, conceptual, connecting, strategic and affective talk. Schauble et al. (2002) also refer to a sociocultural perspective when emphasizing that social interaction and cultural tools are crucial in order to appropriate knowledge, values and expressions. Through interviews they studied staff members' understanding of children's learning when playing with exhibits. They found that the respondents, who worked as pilots, often felt puzzled about how to help the children to enhanced learning. Neither did they felt confident in identifying children's learning and

when and where learning takes place. The staff members in addition framed the task of adults as negotiating a balance between play and learning and by that differentiated play from learning. The question is however in what ways a sociocultural perspective differs from other theories about learning and development and how it affects our understanding of visitors' learning at STCs?

A sociocultural approach to learning

A sociocultural approach to learning derives originally from the culture-historical framework of Lev Vygotsky (1929; 1978; 1986; 1987) developed nearly hundred years ago. A central idea in this theory is that the learning processes and our thinking originate from the social and cultural interaction we are exposed to everyday through encounters with others and our environment. Vygotsky argued that thoughts and higher mental functions are created and developed depending on what mediated tools and signs we use or have access to in this interaction.

Wertsch (1991) argues that mainly three themes exist in Vygotsky's theory; the genetic or developmental analysis, the claim that higher mental functioning in the individual derives from social life and that human action is mediated by tools and signs. He defines (p 28) *tools* as technical means (e.g. computers, graph calculators) and artifacts (e.g. books, cultural products) that exist in our surroundings mediating and affecting what and how we think. *Signs* are defined as psychological tools (e.g. language, symbols, formulas) that are used as means of thinking. In this way scientific languages and scientific concepts constitute tools which we can use to formulate our thoughts about the world. Wertsch describes how our thoughts are mediated by means of tools and signs through stating that "the mind goes beyond the skin" (Wertsch, 1991 p33). This could be restated as the fact that there exists a dialectic relationship between thought and tool. Thoughts are mediated and influenced by human and cultural products embedded in the tool. Simultaneously, as we increase our understanding of how the tool may be used, our thoughts are driven and develop our learning.

However, mediation can not be taken for granted nor is it automatic. Kozulin (2003) argues that mediation must be grounded in *mediation of meaning* since psychological tools derive their meaning only from the cultural conventions that engender them. This means that in order to facilitate the appropriation of new psychological tools, the situation needs to focus on processes and metacognitive awareness about the tools rather than only focus on certain content. Wertsch (1991, 1998) argues that mediated action is strongly connected to mediational means. This implies that our actions above all are created and shaped depending

on what kind of mediation we experience and what mediational means we use. He **claims** that the relationship between the action and the mediational means is that fundamental that you should talk about *individual(s)-acting-with-mediational-means* (p 12) rather than only about discussing individuals' acting.

The study

Until now we have only approached visitors' learning from a theoretical perspective and from the point of view of the current debate within the research community. But in what ways do staff members at STCs approach visitors' learning? What ideas and assumptions about visitors' learning do staff members express when discussing visitors' interaction with exhibits? And in what ways do these ideas and assumptions affect how the staff members reason about the content and the design of an exhibition? The research questions in this study are:

- How do staff members reason about visitors' learning when interacting with exhibits at STCs?
- How does staff members' reasoning intersect with and relate to existing theories about learning within the field of STC research?
- What references of knowledge do staff members refer to when reasoning about visitors' learning and the natural science content?

Methodological considerations

This study is the second part of a larger project whose aim is to explore the assumptions and factors that affect how science in exhibitions is constituted at Nordic STCs. The first article focused different aspects of science that are displayed and in what ways these aspects constitute different images of science (Davidsson and Jakobsson, 2007). The article is based on a questionnaire in which the staff members from 30 Nordic STCs considered the extent to which they displayed different aspects of science in their latest exhibition. The results revealed that **exhibitions today** to a large extent display the wonders of science, presenting science in a product-oriented and unproblematic way.

The reason for choosing a questionnaire was to obtain a general view of different aspects of science as well as to attend to the lack of studies in this area. In this questionnaire a set of questions also concerned visitors' learning. However they proved to be useless when it came to analysing staff members' views of visitors' learning. To come close to answering this question seems to demand

other methodological considerations. The **intention** was rather to explore the staff members' reasoning and how they talk about learning and visitors' interaction with exhibits. The possible respondents were spread over a large geographical area in the Nordic countries, which meant that a personal meeting at each STC was not possible. This problem was circumvented by using telephone interviews as a means to approach issues about learning. **A weakness related to the choice of using interviews is that it is not possible to explore the staff members' reasoning about learning in action, but instead the respondents were asked to comment on this process.** The respondents were selected for the study through purposive sampling (Silverman, 2001; Patton, 2002). The criterion for selection was that the respondents should be responsible for designing and creating new exhibitions at their STC. The purpose of this selection was to create possibilities to study the ways in which staff members' understandings of learning are represented during the planning and constructing of new exhibitions. In all, 17 staff members, from 11 different STCs were interviewed for 40 to 60 minutes. The interview was semi-structured and consisted of a set of open-ended questions. **In order to increase the prerequisites that the respondents would understand the questions in the same way, a pre-test and evaluation of the questions was conducted.** All the respondents were confronted with the same core questions and were given an opportunity to freely reason without interruptions from the interviewer. This was done in order to avoid guiding questions and to increase the reliability of the study (Kvale, 1997). The design of the study also made it possible for the interviewer to ask follow-up questions in order to broaden the understanding of unexpected issues. This reinforced the explorative character of this study.

The research questions focused on the respondents' ideas and assumptions about visitors' learning. They were therefore asked about their understanding of *how learning arises when visitors interact with exhibits*. This question derives from the previous discussion about different models concerning learning at STCs and intends to shed light on the ongoing debate in the field. The research questions also aim to explore what references of knowledge the staff members refer to when reasoning about visitors' learning and the scientific content. The respondents were therefore asked *from where do you acquire knowledge about visitors' learning*. They were also asked *from where do you acquire knowledge about the scientific content*. The **intention** with these questions was to further deepen the understanding of the respondents reasoning and also to relate this to their approach to other scientific areas such as natural science.

Analysis

The transcribed interviews were explored without existing pre-defined categories into which to fit the data. Instead the categories emerged through a two-phase analysis (Patton, 2002). The first phase involved discovering and identifying patterns, themes and relations and resulted in preliminary descriptions of different apprehensions of learning expressed by the respondents. This primary stage revealed a pattern where the respondents seemed to focus on learning in relation to different learning contexts. This means that the respondents related to visitors' learning differently depending on:

- under what circumstances the visit was conducted
- the expected learning outcomes

These two main categories constituted starting points for further analysis in the second phase and were used to successively specify subcategories, which described different circumstances and learning outcomes. The subcategories that emerged, concerning different circumstances, were described as contrasting pairs such as organized – non-organized learning, serious – non-serious learning and hands-on practical – theoretical learning. When it comes to the expected learning outcomes, the analysis revealed a discrepancy between creating an interest in science and learning science.

In the first phase, also the respondents' different references of knowledge about learning were recognized. The respondents' reasoning enlightened different relations between their personal ideas about visitors' learning and different scientific models of learning. These different references seemed to emphasize:

- personal experiences
- professional experiences
- professional education
- external sources
- scientific sources

These categories were used as an analytic tool to categorize the respondents' reasoning through the second phase. The second phase of the analysis sought to test, verify and confirm the recognized categories. These categories were also used to analyse what references of knowledge the respondents referred to concerning the scientific content.

In order to increase the reliability of the study, the data was first analysed by

two independent coders and the results of these analysis were compared. When there were different interpretations, the data material was reanalysed and the categories were successively modified in order to reach a final description.

Results

Since one aim of this study is to focus on how staff members reason about learning, the respondents were asked to reflect on how they believe learning arises when visitors interact with their exhibits. The analysis revealed that most of the respondents express that learning processes differ depending on whether learning arises in formal or informal contexts. Some respondents also make distinctions between practical, hands-on learning and theoretical learning and between serious or non-serious learning. The last distinction refers to comments about that learning occurs differently depending on whether the visitors take the visit seriously or are just playing. The following excerpt (Excerpt I) highlights yet another discrepancy: that the learning processes differ depending on whether or not learning activities are organized.

Excerpt I

I	How do you think learning arises when visitors interact with your exhibits?
Carl	Yes... "hehe" [laugh]... it is very random depending on the reason they are here...
I	Mm
Carl	...are they here together with their class or with some organized education-thing, this is one thing... Then they might be controlled by learning material
I	Yes, right
Carl	...and other things, but if you are here as a visitor who walks around on a Saturday, Sunday then you react in a completely [emphasised] different way
I	Yes
Carl	Then you walk randomly back and forth in the exhibition. You catch something and then you go there... You don't go... in a marked pedagogical track
I	No, right
Carl	And there I usually compare to how I am... so to say... when I visit an exhibition... I don't start with A and finish with Z so to speak
I	No
Carl	But I walk inside. And this looks fun, so I go there
I	Hmm, yes
Carl	So, one should not have blind faith in this pedagogy... the way that it is to be a systematically constructed thing. People, people who go there in leisure hours for entertainment, they don't act that way. On the other hand school classes and everything... that is, that is why you build exhibitions after some form of...
I	Exhibitions turn to

Carl	... pedagogical ideas so that you learn from the one to the other. This also means that each entity in the exhibition should be independent. So, when I go there and look at one thing, then I will understand the things that are right here
I	Right
Carl	Without necessarily have looked at previous things.

Carl claims that there are different reasons to why people visit exhibitions. He asserts that learning arises differently depending on whether a visitor is at the STC in a school context or if they attend the exhibition during their spare time and even emphasises that that is a *completely different thing*. He thus argues that learning arises differently depending on whether or not the learning activity is organized. Carl's statements about organised and non-organised learning seem to be based on his own personal experiences. According to Carl, visitors do not follow a pedagogical track in an organized way. He points out that during leisure time people visit an exhibition unsystematically. If you follow Carl's reasoning though the excerpt is it possible to believe that Carl not only makes a distinction between how learning arises, but also implies that the learning outcomes differ depending on how learning is organised. This possible interpretation is reinforced in Excerpt II where Ted expresses that there exist different learning outcomes depending on whether these derive from an organized, formal activity or from a non-organized, informal one. This view, held by most of the respondents expresses that a visitor at a STC may only acquire some products of knowledge when interacting with exhibits.

Excerpt II

I	How do you think learning arises when visitors interact with your exhibits?
Ted	...wow... for me is it about creating an interest. Then... and I have always seen exhibitions as some kind of... smorgasbord, you can say, right...
I	Yes
Ted	It should tickle their interest and then... then work along on their own... Or how to say it... an exhibition needs not always to give... answers to everything...
I	No...
Ted	But just to create an interest, since an exhibition can never convey the same quantity of knowledge as a written document for example...
I	Okay...
Ted	... or a film. One can use writing restrictively, one may use films and so on... and show. But it still turns... that it is about tickling the interest and in some ways entering deeply in other ways...
I	mm....
Ted	... and that there arises a communication between visitors that you come together with or... or visitors that you might meet... visitors and staff, visitors and teachers

I	Mm
Ted	And through this curiosity arises
I	Mm
Ted	The question is how much... how to say... pure knowledge [emphasised] you convey in an exhibition. I'm not sure of that.

Ted does not really answers the question about how learning arises when a visitor interacts with exhibits, but instead claims that it is about creating an interest about the content. He seems to view exhibitions as a starting point for later knowledge development. Ted thus makes a distinction between creating an interest and learning. In this way he says that learning processes appear differently depending on whether the visitor only becomes interested or actually learns something. A possible interpretation of Ted's reasoning is that it is only possible to reach a "level of getting interested" if you interact with exhibits. To reach a "level of learning" you must participate in other activities such as reading a written document or watching a movie. However, he stresses the importance of communication between visitors, staff and teachers in order to enhance learning. In this way his statements intersect with a sociocultural approach to learning (Vygotsky, 1986, 1987; Wertsch, 1991, 1998) and this is also pointed out as a crucial context for visitors' learning by Falk and Dierking (2000).

He makes a further distinction concerning learning when he reasons about how much *pure knowledge* it is possible to convey from an exhibition. He thereby seems to distinguish general or everyday knowledge from pure knowledge. It is actually not explicit what Ted means with the concept of "pure knowledge" but a possible interpretation is that he is referring to the fact that scientific knowledge exists as independent of personal experiences. Another interpretation could be that Ted uses "pure knowledge" in a similar way as Vygotsky (1986) when referring to scientific knowledge as tools for formulating our thoughts about the world.

In Excerpts I and II, Carl and Ted express that learning arises differently depending on the *circumstances* of the visit which also results in different learning outcomes. These two excerpts represent examples of what most of the respondents (14 of 17) express about this issue. According to a sociocultural perspective (Vygotsky, 1986, 1987; Wertsch, 1998; Säljö, 2005) this division risk reducing what learning includes when distinguishing theoretical from practical learning, serious from non-serious learning, formal from informal learning and organised from non-organised learning. This also means that learning risks being reduced to occurring only in certain specific situations such as in theoretical, serious or organised contexts. Furthermore, this view tends not recounting for visitors' experiences and enjoyment as a part of learning.

Another aim of the study is to investigate what references of knowledge the staff members use when discussing visitors' learning. The respondents were therefore asked to reflect on from where they acquire knowledge in order to develop their understanding of visitors' learning. The analysis showed that more than half of the respondents (11 of 17) state that they do not have any scientific knowledge about this subject and that most of them do refer to other staff members who have that competence. However, nearly all of the staff members in this study do not use scientific references, but instead use their *personal* and *professional experiences* as a foundation when reasoning about visitors' learning (15 of 17). This is highlighted in Excerpt III.

Excerpt III

I	From where do you acquire knowledge about visitors' learning?
Lea	Well, we have a group of educators here who... we assimilate information... some [texts] have been written in this area... and a great deal has been done with both research and written reports and so on...
I	Mm
Lea	I think that... that... yes... well it is I guess different
I	Yes
Lea	We do have teachers here... but when I refer to myself and, then I don't know... one refers very much to... to how one's self works actually ... and if I don't catch it, then I guess no one else understands it either
I	No, right
Lea	And you watch... one watches... and if one shows exhibitions and things like that, then you know what they ask about right?
I	Mm
Lea	What is unclear here? What has not been understood? What kind of questions do they ask?
I	Mm
Lea	And they, you also watch how they move here, what kind of tools they use to understand the content. Do they approach this computer and do they type something? Do they stand and watch these pictures? Do they read the text? You watch that, right...
I	Yes
Lea	And then you need to find levels that... and that is also a problem I believe that you... you... have such an exhibition that is not directly aimed at kids, it actually isn't at all, but still you have to use a language that works for everyone in some way.
I	Mm
Lea	...and that, that... and then it can't be too much information either. You must in some way, you want... I think you should stick to at least two different levels in an exhibition.

When Lea is asked from where she acquires knowledge about visitors' learning, she first answers by referring to other staff members who are museum

educators. But when she refers to herself she states that she does not have that theoretical knowledge. She claims that she creates her personal understanding of visitors' learning by referring to how she acts when she faces a similar situation. By that she refers to her *personal experiences*. Further on, Lea refers to her *professional experiences* about how visitors act in an exhibition. In order to acquire this knowledge she observes the visitors, and listens to what kinds of questions they ask and what tools they use. From these experiences and observations she then tries to define at least *two different knowledge levels*. A possible interpretation of this statement is that Lea refers to that exhibitions should offer various degrees of difficulties on order to encounter visitors' different prior knowledge (Andersson et al, 2003; Stocklmayer and Gilbert, 2002).

Apart from assuming personal and professional experiences as Lea does, there were also respondents who claimed that they use their *professional education* and knowledge as a foundation when reasoning about visitors' learning (6 of 17). This is highlighted in Excerpt IV.

Excerpt IV

I	From where do you acquire knowledge about visitors' learning?
Simon	... well from our background as teachers I would say.
I	Yes
Simon	I guess we haven't added any new pedagogical ideas so... no, it's our teacher experiences that is the basis of that.
I	[...] What theories about learning do use when planning your activities and exhibitions?
Simon	... well, we do not discuss in terms of Piaget and so, but we talk about the practical learning.
I	mm... can you give me an example?
Simon	Yes, it is just that, that the visitors are confronted with concrete questions which they solve using simple tools.

When reading this excerpt it becomes obvious that Simon makes himself a spokesman for all the staff members who have a background as teachers. He states that they use their *professional education* as a foundation for their knowledge about visitors' learning. At the same time he argues that this does not include new pedagogical findings or ideas. A possible interpretation is that he does not claim to use scientific sources about learning when they discuss activities or plan exhibitions. This is reinforced when Simon explains that *the visitors are confronted with concrete questions which they solve using simple tools*.

Apart from personal and professional experiences as well as professional education, a few respondents also allude to *external references* when discussing

visitors' learning (4 of 17). Sarah in Excerpt V provides an example of this.

Excerpt V

I	From where do you acquire knowledge about visitors' learning?
Sarah	... well, when it comes to me it's... I studied science communication as a subject, a qualification then
I	Yes, right
Sarah	And then I've worked since, what is it, since 1985 with this. And worked as a teacher... so when it comes to me I've tried to bring what I can to those projects I've worked in ...and in other special exhibitions at the centre
I	Mm
Sarah	So... it depends a lot, I believe, on the curators previous experiences
I	Yes
Sarah	Collaboration with educators. We have museum educators on our staff so to say. That is perhaps the most important part... to emphasise that we have museum educators that have pedagogic education
I	Mm
Sarah	And then we have a collaboration with teacher education and with the University
I	In what ways do you cooperate with teacher education?
Sarah	Yes, we develop some of the programs which they look at... and we also have students doing their practical training here and so...
I	Yes
Sarah	Perhaps that is important, yes and also engineering students

Sarah mentions several references where she claims that she acquires knowledge about visitors' learning. She first refers to her *professional education* with a special emphasis towards science communication. Further on, she points out her *professional experiences* both as a teacher and as an employee at the STC. She also reasons about how other staff members' acquire knowledge about visitors' learning and states that it probably depends upon their previous experiences. This possibly means that she does not refer to their theoretical knowledge about learning, but to the curators' previous encounters. Nevertheless, she points out that the most important part in developing knowledge about visitors' learning, is the collaboration with educators. Apart from discussing the personal and the professional references of knowledge, Sarah also refers to collaborations between the STC and universities. These could be referred to as *external references* when discussing from where they acquire knowledge about visitors' learning. The collaboration seems to consist of accepting students for practical training and of creating special programs aimed at teacher students. However, it is not clear whether their collaboration in addition aims at affecting

the content and the design of the exhibitions in order to enhance visitors' learning.

By analysing Excerpt III, IV and V, it is possible to distinguish four different references of knowledge when it comes to those staff members refer to when reasoning about visitors' learning. The first and most commonly used reference is *personal experiences* emphasised in Excerpt III, where Lea discusses her own actions when attending an exhibition. In addition she refers to her *professional experiences* which she has acquired through her informal studies of visitors as to what they do and what they ask about when interacting with exhibits. Another used reference is *professional education* and is exemplified by Simon who alludes to his experiences as a teacher. The final reference is *external references* and is shown in Excerpt V where Sarah, apart from her professional and personal experiences as well as her professional education, also discusses collaborations with teacher education and universities.

A third aim of this study is to compare what references of knowledge staff members use when reasoning about visitors' learning in relation to how they reason about different references of knowledge within other scientific areas. The respondents were therefore asked to consider where they acquire knowledge about natural science content when planning exhibitions. The analysis revealed that nearly all of the respondents (15 of 17) explicitly said that they use *references from the natural science community* as a basis for constructing exhibitions. This means that to a high extent they have contact with and use researchers' expert knowledge within different natural science areas. A few of the respondents additionally state that they use their own knowledge about natural science or study by themselves to acquire more information within the subject area. In Excerpt VI, Sue describes what references she uses when planning the scientific content for exhibitions.

Excerpt VI

I	From where do you acquire knowledge about the scientific content? You talked before about the fact that you cooperated with a technical government authority and...
Sue	Mm
I	... is it common for you to use external expertise?
Sue	Yes, we try to do that a lot. It is like this, we, we also have three responsible authorities. We also belong to the University, right
I	Yes
Sue	We were in the beginning a project at the university. And then, when we were about to reorganise this... They had to place us somewhere else and we ended up in the local government.
I	Mm
Sue	But we still have a board consisting of [representatives from] the University, the county

	council and the local government. So, that is what I mean, we have the possibility to have external help both from the county council [...] and the University. So we try to use this. It is important when you do exhibitions, that it isn't free fantasies, right.
I	No, right
Sue	Because, it should be real things ... and we are really careful about this... checking that this is true [laugh]
I	Yes
Sue	Because it is like this, as time goes, one's own knowledge turns old and many things happen, you notice, right.

During the discussion, Sue has previously talked about the fact that the STC used knowledge of the technical government authority and continues to refer to other scientific references of knowledge when reasoning about the content of the exhibition. She states that having these three different responsible authorities creates special opportunities to incorporate current knowledge about specific scientific areas. She also argues about the importance of these contacts in order to avoid *free fantasies*. Further on, Sue emphasises this by claiming that the STC needs to examine whether or not the scientific knowledge is true. It is not entirely clear what she means about true knowledge, but at the same time she implies that something exists that can be called true knowledge within natural science. Finally she reflects that her own knowledge about natural science becomes outdated.

When it comes to the natural scientific content in exhibitions, Sue in Excerpt VI, refers to *references from the natural science community*. This is a common reasoning through out the data and Sue constitutes only one example of this view. This relation to scientific references of knowledge differs from the previous results. In Excerpt I-V another commonly occurring phenomenon is explicit. When the respondents reason about visitors' learning nearly all primary use their personal and professional experiences. Also professional education and external references are used by some of the respondents. In Excerpt VI, Sue carefully points out that it is important that the natural scientific content not is based on free fantasies. There is thus a discrepancy in what references of knowledge staff members use when reasoning about natural science content in exhibitions, in relation to which they use when discussing visitors' learning. Sue also emphasises the necessity in using other scientific references of knowledge, since her own information about natural science becomes outdated. This view is not found in any discussion about visitors' learning.

Discussion

The principal aims of this article were to investigate staff members’ ideas and assumptions about visitors’ learning. The results reveal that the respondents refer to learning processes differently by distinguishing organised from non-organised learning, theoretical learning from practical hands-on learning and serious from non-serious learning. According to most of the respondents, these learning processes conclude with different learning outcomes. It is also evident that most of the respondents express that their exhibitions primary intend to increase visitors’ interest in science and do not emphasise the possibilities for learning. Some of the staff members thereby give the impression of separating the aim of creating an interest from learning. Taken together, the respondents’ division of different learning processes and its knowledge products can in this way constitute diametric extremes. This view can be seen as they express a kind of dualistic understanding of learning and knowledge, which could be described as epistemological reductionism.

But what consequences does this approach to learning bring? An obvious risk is that visitors’ learning is only seen to occur in certain specific situations and do not recount for enjoyment and experiences as learning. This view might lead staff members to not realize the possibilities for learning that could be provided to visitors. In a sociocultural approach, a crucial assumption is that learning processes derive from the all social and cultural interactions we are exposed to through encounters with others and our environment (Vygotskij, 1987; Wertsch 1991; Säljö, 2005). In a STC context this could mean that when visitors interact with exhibits or with each other, new thoughts may be mediated independent of whether the situation is non-organised, non-serious or hands-on practical. According to a sociocultural perspective, it is hence possible to understand the visitors’ learning from how they interact with peers and curators as well as the available activities in exhibitions.

Another aim of this study was to explore the references of knowledge staff members refer to when reasoning about visitors’ learning. The results revealed personal experiences, professional experiences, professional education and external references as four main sources. However most of the respondents depend upon their own personal experiences when reasoning about visitors’ learning. When it comes to professional experiences, some respondents conduct informal observations of what the visitors do and what they ask about. However eleven of 17 respondents explicitly state that they do not have any scientific knowledge about learning despite the fact that they work with the planning and construction of new exhibitions. Meanwhile it is possible to identify that some

respondents' reasoning intersect with existing theories about learning. For example, a few of the respondents emphasis the importance of visitors' communication in order to enhance learning which is also pointed out by Falk and Dierking (2000) in the contextual model of learning. It is also possible to discern that some respondents refer to visitors' prior knowledge (Anderson et al, 2003) as a crucial factor to be able to understand how visitors' learning is developed through interaction with exhibits. This factor is also a prerequisite for learning in the PAST framework of Stocklmayer and Gilbert (2002).

When it comes to how respondents reason about the natural scientific content, a completely contrasting image appears. Nearly all of the staff members explicitly express that they use references from the natural science community and refer to researchers' knowledge when constructing new exhibitions. Unfortunately, this study is not able to explain why staff members express this clear difference in how they relate to the natural science content compared to how they relate to visitors' learning. Do staff members view visitors' learning as an area in which it is impossible to raise questions and construct scientific models in order to describe learning? Or do staff members experience the existing models as irrelevant when planning new exhibitions?

When discussing theoretical models of learning, Falk and Storksdieck's study (2005) and the contextual model of learning (Falk and Dierking, 2000) highlights the complexity of describing the individual factors which are decisive for visitors' learning. However, a model aimed at describing all possible factors that might influence visitors' learning, risk to loose focus on the essence of a theoretical model of learning. This means that the visitors' meaning making processes and their actions when interacting with exhibits tend to be out of focus when studying learning at STCs. The contextual model also does not seem to consider the combination of different theoretical frameworks. Consequently different epistemological approaches are used which can be problematic to combine. An example of this is the use of an individual constructivistic approach to learning and an attempt to implement a sociocultural perspective.

A sociocultural perspective (Vygotsky, 1987; Wertsch 1991; Säljö, 2005) focuses on meaning making processes, which have their origin in interactions between individuals and between individuals and different tools or signs. This means that the relation between the visitors and the exhibits could constitute the core of a model of how learning arises at STCs. It is thereby possible to understand and to study how visitors take action when interacting with provided mediational means. This means that we may study in what ways different tools and signs mediate the visitors' thoughts and actions. The exhibitions can in this

way be viewed as tools or artifacts which to different extents enable mediation. From Kozulin's (2003) reasoning about mediation of meaning, it is possible to study to what extent exhibitions make cultural conventions and cultural development explicit. But it is not until visitors interact with exhibits that it is possible to investigate how the exhibits accomplish support for the development of new psychological tools. Thus, the relation between visitors and the accessible resources in an exhibition can form a foundation for a model aimed at understanding how learning arises and develops at STCs. Such a model could, in addition, constitute starting points and guidelines for staff members when planning and constructing future exhibitions.

However, Kozulin (2003) argues that mediation is not for granted and claims that tools and signs only derive their meaning from the embedded cultural conventions. This means that when an artefact is separated from its cultural milieu and put on display in an exhibit, it risks losing its mediational potential. It is therefore necessary to re-provide mediational qualities to the artefact through visualizing processes which engender the artefact and display its cultural-historical background. The situation also needs to focus on the visitors' metacognitive awareness about the tools and signs in the artefact. The concept of mediation could thus be used as a tool when creating new exhibitions and may address questions for the staff members such as: What do we want the visitors to focus on and discuss when they encounter this artefact? What actions do we wish visitors to take when interacting with this tool? How can we implement an artefact into an exhibition without losing its mediational qualities?

This study has actually only explored staff members' reasoning about learning on display. This means that we have investigated how staff members claim to reason when planning new exhibitions and not in what ways they really refer to learning in action. Future studies therefore could take an ethnographic approach and focus on staff members' actions and assumptions about learning when constructing new exhibitions.

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